

TITLE: INTRODUCING INTREPID DIGITAL MICROWAVE

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ABSTRACT

Intrepid Digital Microwave is a Bistatic Microwave outdoor perimeter security sensor. It uses Digital Signal Processing to provide optimal performance in a wide variety of applications and environmental conditions. As the latest member of the Intrepid family of products it incorporates a unique power and data network that supports remote diagnostics and service features as well as a cost effective PC based display and control capability.

Southwest Microwave Inc. (SMI) introduced the world's first commercially viable Bistatic Microwave intrusion detection sensor in 1971. Bistatic Microwave has become the paradigm for high security perimeters, and SMI products have become industry standards. This wealth of experience is the basis for the design of the **Intrepid Digital Microwave**.

Since **Intrepid Digital Microwave** operates at K-band (24 GHz) similar to the proven 310B it provides superior antenna beam control and target definition. DSP is used to recognize the unique bistatic target signatures of intruders walking, running, jumping or crawling through the detection zone so as to minimize the number of Nuisance Alarms caused by environmental changes. By emitting less power this sensor meets both North American and European radio regulations.

This paper describes the system concept and the unique features of **Intrepid Digital Microwave**. The importance of these features is illustrated in a number of typical site applications.

INTRODUCTION

There are basically two types of Microwave intrusion detection sensors; the Bistatic "Link" and the Monostatic Transceiver. Southwest Microwave introduced its first Bistatic Microwave in 1971. It has become one of the most widely used outdoor perimeter security sensors. Each Link comprises a Transmitter and Receiver located at opposite ends of the detection zone. Intruders moving in the Detection Zone are detected as they disturb the signal coupled into the Receiver. Southwest Microwave introduced its first Monostatic Microwave in 1980. With a Monostatic Microwave sensor a Transceiver is located at one end of the Detection Zone and the intruder is detected by the signal reflected from the moving body. The Intrepid Digital Microwave is the first Bistatic intrusion detection sensor using Digital Signal Processing (DSP) produced by Southwest Microwave.

In 1997 Southwest Microwave introduced the Intrepid Micropoint fence disturbance sensor. The Digital Microwave described in this paper is the second sensor in the Intrepid family of outdoor perimeter security sensors. The new Digital Microwave has many of the same power distribution and data communications features of the Micropoint product. They share the same PC based installation tools and display software.

INTREPID DIGITAL MICROWAVE MODULES

The basic Intrepid Digital Microwave comprises a Transmitter Module and a Receiver Module each housed in the familiar Southwest Microwave radome shown in Figure 1. The radome is fastened to the back plate using six Quick Release Latches to provide easy access to the electronics during installation and service. A tamper switch monitors the removal of the radome.



Figure 1

Intrepid Digital Microwave operates at 24.125 GHz (K band) meeting both US and European radio regulatory standards. By operating K Band it is immune to many of the interference problems associated with X Band (10.525 GHz) and it provides much more precise target signatures.

A modified parabolic dish antenna is used in both the Transmitter and the Receiver to create a well-defined detection zone. This unique antenna creates a field with a narrower horizontal pattern than vertical pattern so as to avoid nuisance alarms from nearby moving objects while maintaining a vertical pattern that detects jumpers and crawlers.

The Transmitter emits a crystal controlled modulated pulse, which is mixed with a crystal controlled LO in the Receiver to produce a precise IF frequency. There are 6 jumper controlled modulation frequencies (Channels) so as to avoid mutual interference in multiple link sites.

The Transmitter operates from a nominal 12-volt DC power source and draws less than 30 ma. A Programmable Logic Array (PLA) is used to control the Transmitter with minimal circuitry.

The Receiver uses a switching power supply operating from a 10.5 to 60 volts DC power source. It draws 150 ma at 12 volts, providing a cost-effective power distribution network. Each Receiver has a microprocessor and a PLA to control the hardware, perform the Digital Signal Processing (DSP) and communicate over the MUX Line when required. Tamper and Alarm relays are provided enabling the unit to be used as a stand-alone sensor.

The MUX Line is an RS485 data network that accommodates up to 32 nodes and can extend up to 5000 feet when required. Each node on the line is given a unique address using a DIP-Switch.

A Systems Interface Module (SIM) provides additional relay input and output connections to the MUX Line. It provides for 8 relay outputs and monitors up to 8 contact closure inputs. It can be used to provide the traditional relay output interface to an alarm panel or out on the perimeter to collect data from auxiliary sensors. The SIM along with an RS232 Adapter can provide an ASCII data interface to other security equipment such as a video switcher. The SIM is housed in the standard Intrepid enclosure.

An Intrepid RS232 Adapter card or an RS422 Adapter card can be used at any SIM or Receiver to connect to a PC. The Receiver has one Adapter port while the SIM has two. The SIM has two ports so that it can communicate with a PC and a modem simultaneously.

A PC running the Intrepid Map Monitor can be used to annunciate alarms collected from Microwave Links and SIM units over the MUX Line. This is the same color graphic map display used with MicroPoint and by using a second serial port it can be used to monitor both the MicroPoint fence sensor and the Digital Microwave sensor on the same map. Its simple three key operation makes an effective operator interface.

A Third Party Interface DLL is available for the user who wants to tie the Intrepid system into a larger display and control system running under Windows on a PC.

BASIC LINK PARAMETERS

The Detection Zone created by a Microwave Link is illustrated in Figure 2. The Transmitter and Receiver Modules that comprise the Link are mounted on rigid posts at a height 24 to 36 inches depending upon the adjustment during the "Alignment" procedure and the security detection requirements of the site.

The Transmitter and Receiver modules are spaced 50 to 800 feet (15 to 244 meters) apart. A special Short Range antenna can be used to obtain wider Detection Zones for special applications such as across gateways.

The intruder disturbs the equal-sensitivity lines shown in Figure 2 causing a change in the received power at the receiver. Because of the antenna field pattern, the sensitivity curves intercept the ground some distance in front of each antenna, which means one must overlap adjacent links to ensure detection of crawling intruders. The "Basket Weave" shown in Figure 2 with modules offset from the Centerline by an Offset Distance is one means of ensuring that each module is protected by the adjacent Detection Zones. The Crossover Distance, X , is the distance from the module to the start of the Detection Zone. The Detection Zone should be level and free of trees, shrubs and any moving objects. Typically the Intrepid Digital Microwave security system is deployed near one or two perimeter fences. In designing the security system it is important that the Detection Zone not intercept a fence so as to avoid nuisance alarms caused by fence motion.

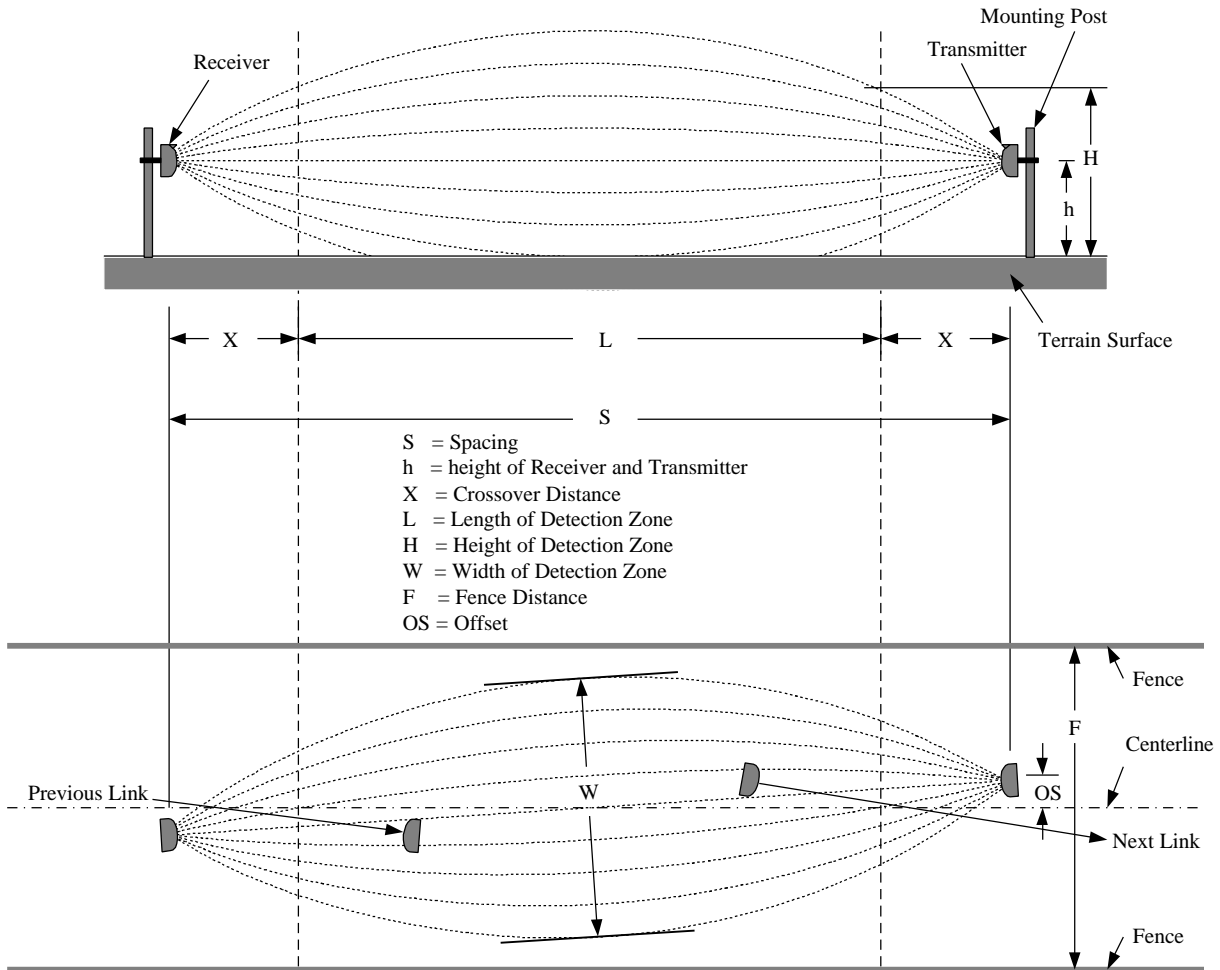


Figure 2

Once installed, the Transmitter and Receiver modules must be “Aligned”. The mounting height of the two units is important during the Alignment process. During the setup procedure the Receiver is put into “Alignment Mode” and the installer measures the “Alignment Voltage” using a standard multi-meter. When the link is in proximity to fencing it is also necessary to move the units laterally to maximize the Alignment Voltage. During the Alignment process the maximum height of the modules is determined by the need to detect crawling targets at the crossover point. The minimum height of the modules is determined by the need to achieve a particular minimum Detection Zone Height. Once the link is properly aligned the installer adjusts the Sensitivity / Threshold potentiometer on the Receiver to set the detection zone width and the detection at the crossover point.

DIGITAL SIGNAL PROCESSING

The microprocessor in the Receiver performs the DSP and supervises the communications. A low speed digitally controlled AGC circuit is used to maintain a fixed

Alignment Signal at the input to the Analog to Digital Converter (ADC). This AGC tracks environmental changes but is too slow to track intruders so that the ADC monitors the changes caused by intruders.

There are three Detection Channels in the DSP. The first is a High Speed Channel, which is set to detect a person running or jumping through the Detection Zone. The second is a Low Speed Detection Channel, which is set to detect a walking person or a person crawling on hands and knees through the Detection Zone. The third is the Stealth Crawl Detection Channel which is set to detect a very slow “belly crawl” intruder while rejecting nuisance alarms due to heavy rain. If any one of the three channel responses exceeds the thresholds an intrusion alarm is declared.

When a person runs through or tries to jump over the Detection Zone the response tends to be large but very brief. The intruder tends to block a significant portion of the main transmission path. The High Speed Channel looks for the unique signature associated with this type of target and responds very quickly.

When the intruder moves more slowly we can integrate the response longer to improve the Signal to Noise Ratio (SNR). In this case the intruder can try to crawl under the main transmission path to avoid detection. This can increase or decrease the signal at the Receiver depending upon the phasing of the signal reflected from the terrain. The Low Speed channel uses unique peak to null tracking filters to measure the peak to null amplitude of such a target in the presence of environmental changes such as due to rain.

In high security applications there is the need to detect intruders who try to move extremely slowly under the main transmission path by laying prone on the terrain and propelling themselves with minimal movement of hands and feet. The response to this “belly crawl” is similar to the response caused by heavy rain. Fortunately this type of intrusion takes a relatively long time allowing much more sophisticated signal processing. The Stealth Crawl Channel uses a Fast Fourier Transform (FFT) to filter out environmental responses and detect this type of intruder.

There is an Alarm Threshold and an Event Threshold for each of the three Detection Channels. Default ratios relating the High Speed, Low Speed and Stealth Crawl channels and the Alarm to Event Threshold are stored in flash memory. This means that all thresholds are adjusted when one selects a Low Speed Alarm Threshold. This threshold is set by a potentiometer on the Receiver and/or as a Control Parameter using a PC running Site Manager software. Hence the installer can setup an Intrepid Digital Microwave without a PC or any special test equipment. A simple voltmeter is used during the alignment process and the Sensitivity/Threshold potentiometer is adjusted to optimize performance. Using a PC the installer can further optimize the sensor performance using the Site Manager software to adjust the various filter constants and relative thresholds to adapt the sensor performance to meet the specific site requirements.

One of the unique features of the Intrepid Digital Microwave is the use of an Alarm and Event Thresholds and the recording of Event/Alarm data. These data are stored in flash

memory in each receiver. They can be retrieved using a PC running Site Manager software to provide quantitative guidance in adjusting the various Control Parameters to optimize performance.

Another unique feature of the Intrepid Digital Microwave is the Out Of Alignment Alarm. In most other Microwave Links the sensor performance can be altered without operator knowledge by an antenna being physically knocked out of alignment or an object being left in the Detection Zone. While these sensors will generate an alarm when this occurs they continue to perform in a degraded manner once the alarm is acknowledged with no warning that the performance is degraded. One of the more common examples of this occurs when a truck parks close to the Detection zone. The sensor alarms when the truck moves into the zone but the signal reflected off the truck can make the sensor create false alarms or to not detect a legitimate intruder. With the Intrepid Digital Microwave the Out Of Alignment Alarm warns the operator that the performance is degraded.

SITE MANAGER DISPLAYS

While the Intrepid Digital Microwave can be installed and used without the aid of a PC, Site Manager software is available to aid in the installation and support of the product. There are three real time displays and four off line diagnostic displays that are very similar to those used in the MicroPoint product.

The **Input Display** is shown in Figure 3.

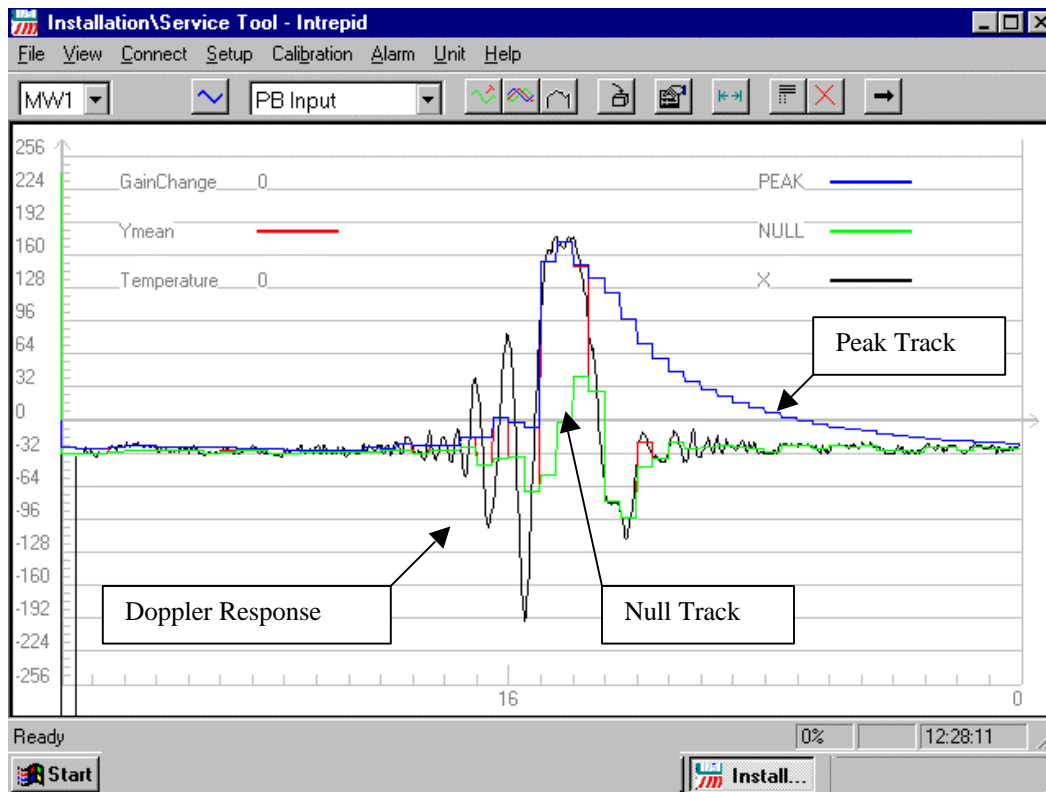


Figure 3

This “water fall type” display moves from right to left showing the Doppler, Filtered Doppler and Low Speed Peak and Null responses.

The **Absolute Response Display** shown in Figure 4 is a “water fall type” representation of the High Speed, Low Speed and Stealth Crawl responses relative to the Event and Alarm Thresholds set for each channel expressed in dB. When any one of the three traces crosses the Event or Alarm Threshold an Event or an Alarm is annunciated and recorded in the Event /Alarm history file.

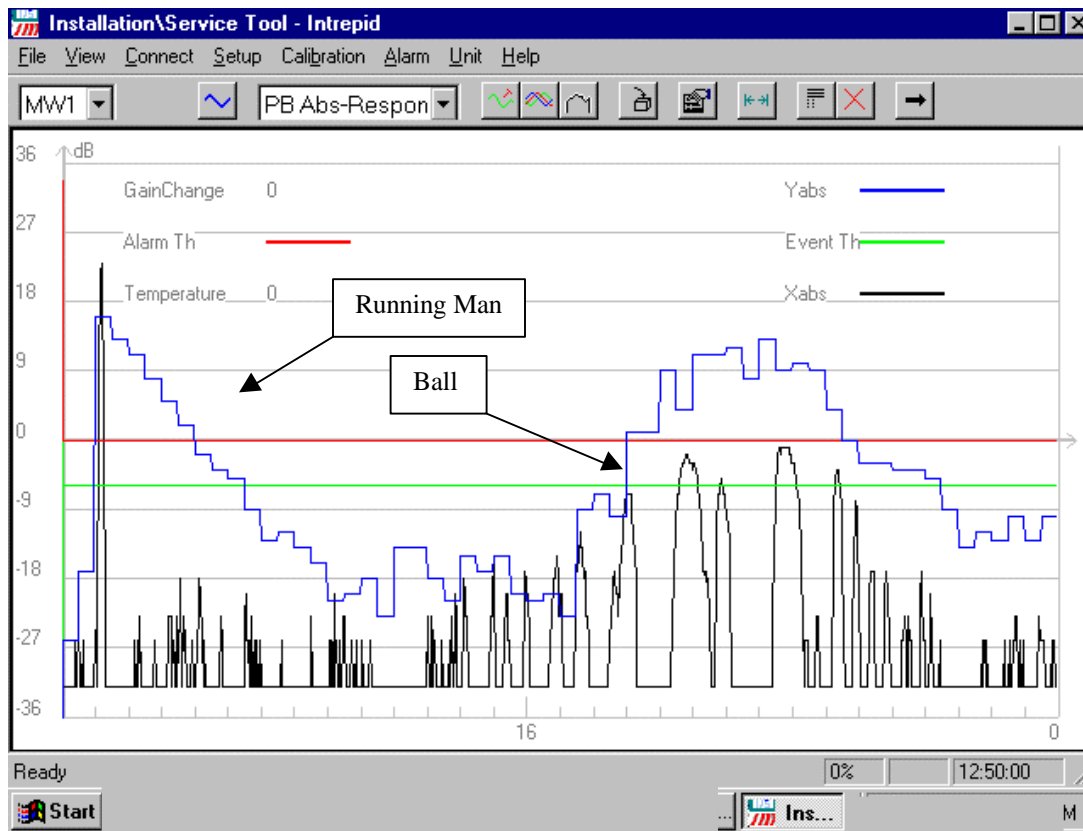


Figure 4

The target on the left is that of a running man while that on the right is a ball pulled slowly through the Detection Zone.

The **FFT Display** presents the linear amplitude of the frequency components of low speed target responses with 16 frequency bins from DC to 1.9 Hz. Each bin is 122 millihertz wide. This information is used to define a filter to detect the Stealth Crawling intruder while rejecting environmental effects.

INTREPID SYSTEM

As shown in Figure 5 multiple Digital Microwave Links can be interconnected so as to benefit from the Intrepid power and data network. Each Receiver can be powered with

10.5 to 60 volts DC. This means that one pair of relatively small gauge wires can be used to power multiple Receivers from one centrally located power supply. Each Receiver creates a 12 V DC output to power the Transmitter modules and auxiliary sensors. A multi-conductor cable is used to interconnect the units. It includes a pair of wires for the RS485 data network, which supports up to 32 nodes with each node being assigned a unique address using a DIP Switch. Operating at 57.6 k baud this data network can provide communication among the distributed Links for up to 5000 feet of perimeter.

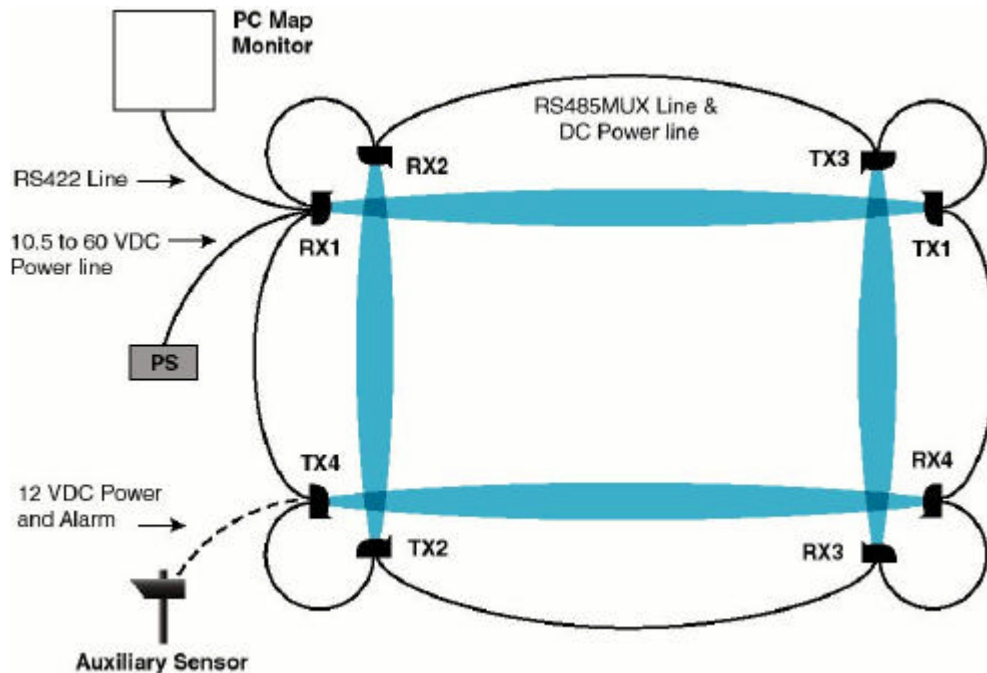


Figure 5

The Receiver Modules accept up to four alarm contact inputs and provide 12 volt DC output to interface to auxiliary sensors. When used in the networked configuration the relay outputs on the Receivers can be used to switch equipment on the perimeter.

A modem can be connected to the SIM to provide remote support to the site. When this connection is enabled a serviceman at a remote location has access to all of the Site Manager Displays. Using the Alarm/Event Record downloaded from each of the Receivers one can determine how any particular link is performing. With this information he can often adjust Control Parameters to fix site problems without having to go to the site.

Summary

Southwest Microwave has used its many years of microwave experience and its more recent Intrepid MicroPoint experience in the design of the Intrepid Digital Microwave. It provides a whole new approach to the use of microwave perimeter security. The benefits of K band operation, the unique antenna pattern and DSP provide improved performance. The Intrepid system power and data capabilities reduces installation and maintenance costs.